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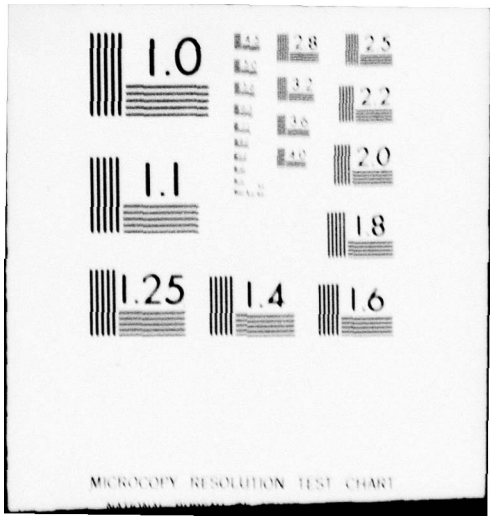
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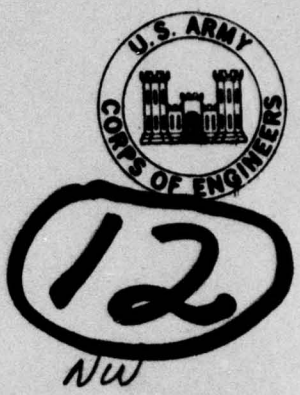

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Special Report 78-17

September 1978

EFFECTS OF WINTER MILITARY OPERATIONS ON COLD REGIONS TERRAINS

G. Abele, L.A. Johnson, C.M. Collins and R.A. Taylor

Prepared for
DIRECTORATE OF FACILITIES ENGINEERING
OFFICE, CHIEF OF ENGINEERS
By

COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
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Observations were made on the 1977 winter military maneuver sites south of Fairbanks to obtain base line data for monitoring terrain and vegetation recovery from the impact of winter trail preparation, and vehicular and troop activities in various terrains and vegetation types.

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PREFACE

This study was conducted and this report was prepared by Gunars Abele, Research Civil Engineer, Applied Research Branch, Experimental Engineering Division; and by Lawrence A. Johnson, Biologist, Charles M. Collins, Research Physical Scientist, and Sp. 6 Richard A. Taylor, Alaska Projects Office. Dr. Terry T. McFadden, Chief, Alaska Projects Office, helped to formulate this study program and reviewed this report. Captain G. Cameron Appel, CRREL, observed the 1977 winter maneuvers and recorded the activities pertinent to this study.

This work was performed under DA Project 4A762730AT42, Task A4/E1, Work Unit 005, Damage to Cold Regions Terrain by Military Operations.

This report was technically reviewed by Dr. Terry T. McFadden of CRREL and LTC. R.A. Dixon, U.S. Army Combat Developments Activity (Alaska).

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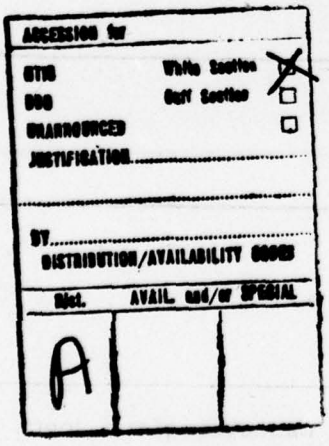

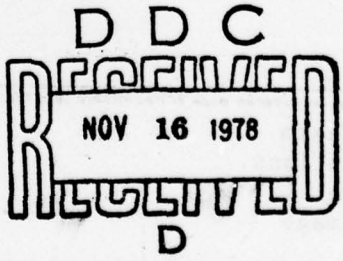

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ILLUSTRATIONS

INTRODUCTION

For a number of years, the U.S. Army has been conducting winter exercises in central Alaska to maintain its capability to function effectively during adverse environmental conditions and to identify specific personnel and equipment problems which limit combat operations in a severe winter environment. These exercises, or maneuvers, are usually conducted during January or early February in the Fort Wainwright (Fairbanks) area.

Recently, primarily in response to the rather visible display of ecological impact awareness by many, and in particular the regulations established by the Environmental Protection Agency (EPA), as well as the state of Alaska, a need has developed for information and data on the effects of military operations on the environment. While military reservations are not bound by most of these regulations, ecological impact data are needed to establish an impact data baseline for various military activities on various terrains during various environmental conditions. Such baseline data would permit comparison between activities (such as types of vehicular traffic), terrain types and the effect of the season (time of year) on the relative degree of impact. If military activities (other than during time of war) were to be conducted in areas other than those under military jurisdiction, such data would be needed to prepare an environmental impact statement.

Observations of the 172nd Infantry Brigade winter maneuvers were done during January 1977[1] to record the type and extent of activities and thus identify the causes should any subsequent impact be observed later.

The mareuver areas were visited during early August 1977 to observe and record the condition of the maneuver areas and to establish specific observation sites which will be used to monitor yearly the response of the terrain to military troop activities.

It should be noted that the initial plan included paying particular attention to the effects of off-road vehicular traffic on the terrain, since this type of activity can leave the most obvious signature and frequently the most significant long range impact. However, during the 1977 winter maneuvers no off-road vehicles, except snowmobiles, were used for cross-country traffic. Vehicular traffic was limited primarily to wheeled vehicles operating on trails prepared by bulldozers. Consequently, any damage caused by ground transportation activities during the exercise was the direct result of the trail preparation, not the subsequent vehicular traffic on these trails. Therefore, vehicle impact data in this study are limited primarily to the effects of bull-

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[1] Appel, C., Trip Report, CRREL, 7 April 1977.

dozer trail clearing activities, and the recovery (or degradation) rate of the disturbed terrain will have to be related to such disturbance parameters as the depth of bulldozer blade penetration or the amount of terrain surface and vegetation removed in a variety of terrain conditions.

DESCRIPTION OF STUDY

Site Selection

The 1977 winter maneuvers were conducted in an area south of Fairbanks (Figure 1), where maneuvers have also been held a number of times during previous years.

The trails used during the winter maneuvers traverse a variety of terrain conditions and vegetation types. Also, the preparation of the trails with bulldozers resulted in various degrees of disturbance to the terrain surface. In some areas the bulldozer blade had removed most of the snow cover without any significant damage to the vegetation below. In other areas the top several centimeters of the organic mat had been removed, exposing the organic and mineral soil, in some cases reaching the natural water level.

Some of the trails had been originally cut a number of years ago and used during previous maneuvers; other trails were prepared during the last maneuvers (winter of 1977). Since the dates of preparation and the equipment used were known only for the new trails, observation sites were established only on these trails.

A total of 11 sites, representing most of the trail conditions, were selected for close inspection and subsequent monitoring to assess the rate of either recovery or continued degradation of the newly cut trails. The sites were marked with numbered stakes, Nos. 10 through 20. The approximate site locations are indicated in Figures 2 and 3, and their characteristics are described later, together with the observations of the impact at each site.

In addition to these specific monitoring sites, several other sites in the Blair Lakes troop concentration areas were selected to observe the impact of troop activities other than vehicle traffic and trail preparation.

Observations

At each of the 11 monitoring sites, the following observations were made:

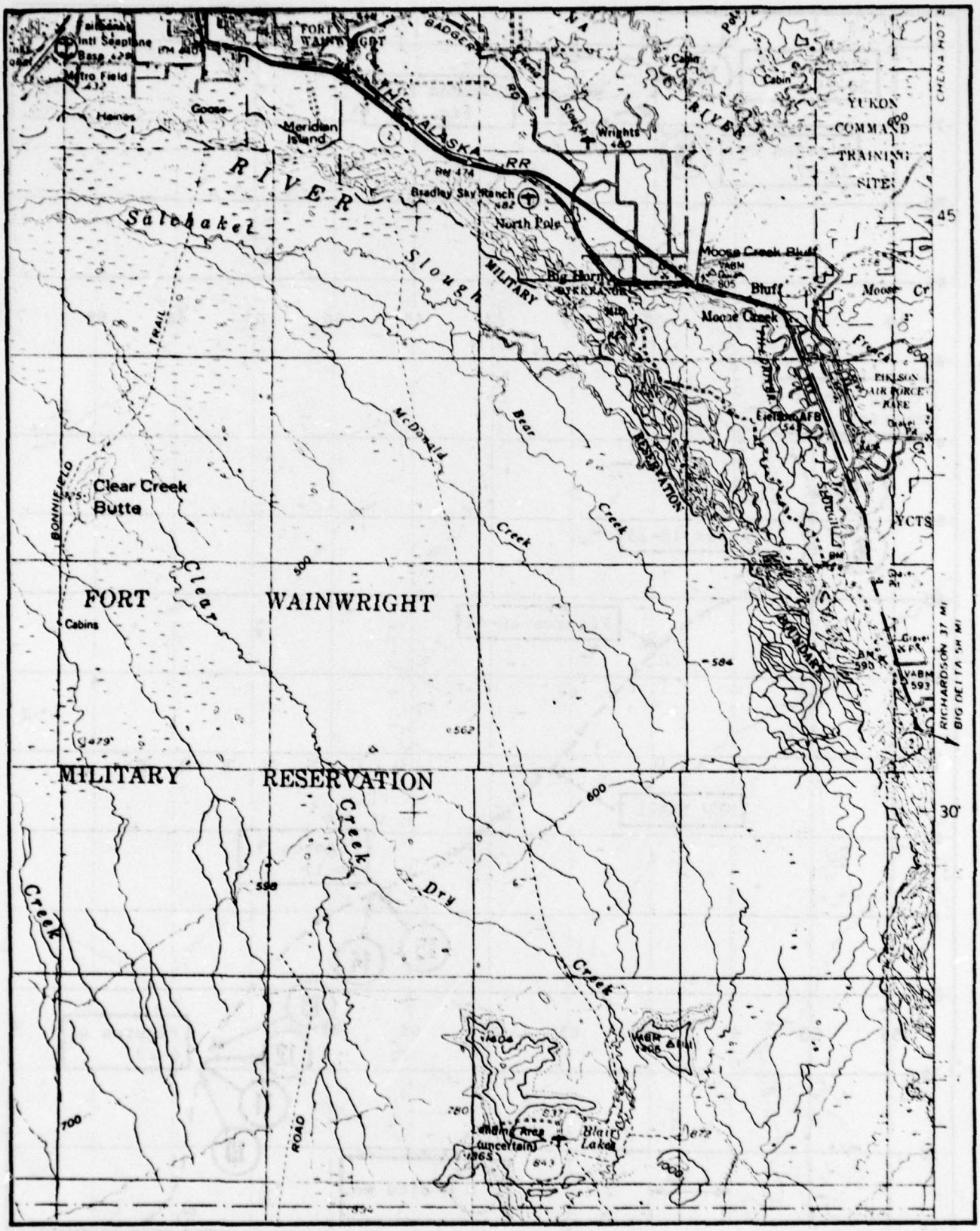


Figure 1. Maneuver area location map.

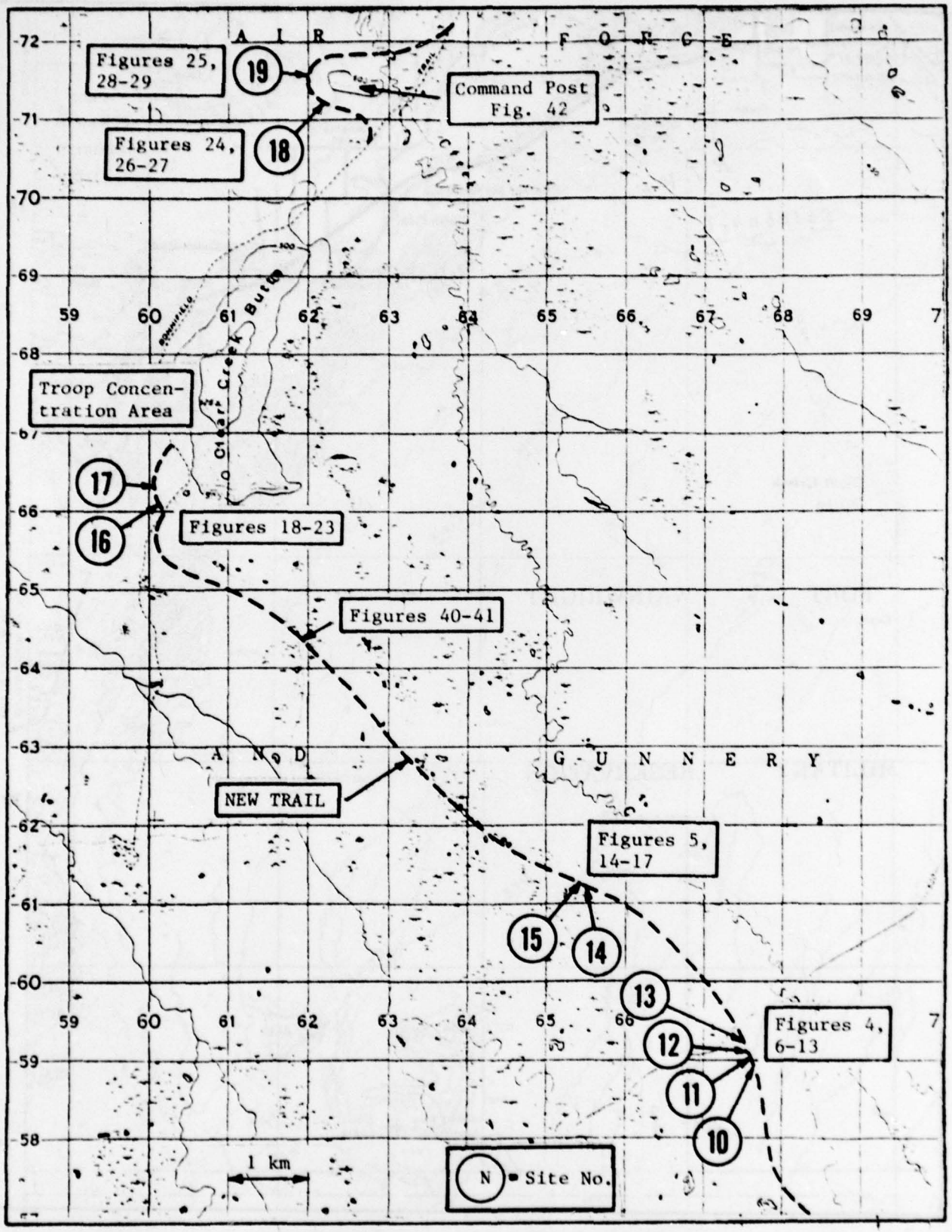


Figure 2. Clear Creek Butte area

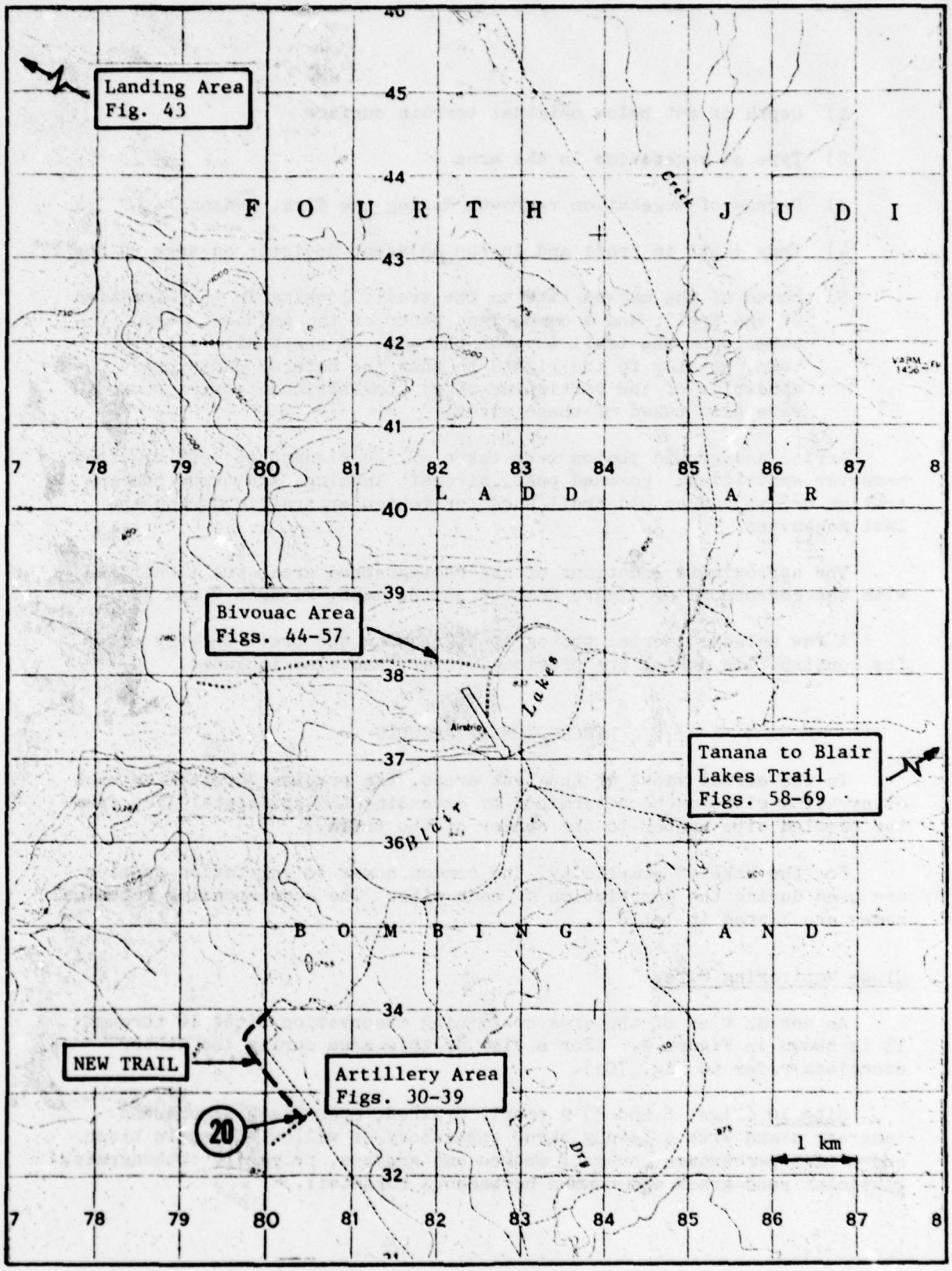


Figure 3. Blair Lakes area

1) Depth of cut below original terrain surface

2) Type of vegetation in the area

3) Degree of vegetation regrowth during the first season

4) Thaw depth in trail and in the adjacent undisturbed area (9 Aug 77)

5) Photo of the marked site on the trail, looking in the direction of the trail, and a comparison photo of the adjacent area, taken from the trail towards the edge of the trail (a 90° turn, usually to the right) to show the natural undisturbed condition of the particular site. Low altitude aerial photos were also taken of these sites.

Aerial and ground photos were taken of the signatures left by other maneuver activities: command post, aircraft landing, and troop concentration areas, and an old trail used for vehicular traffic during the last maneuvers.

The approximate locations of the photographed areas are identified with the corresponding figure numbers on the maps, Figures 2 and 3.

A few selected aerial photographs, showing the trail shortly after its construction during the previous winter, are also included.

DISCUSSION OF RESULTS

In the aerial views of the test areas, the precise location of each observation site can be determined by extending the horizontal line from the circled site number to the center of the trail.

For the sake of simplicity, the common names of vegetation species are used during the description of each site. The corresponding botanical names are listed in Table 1.

Close Monitoring Sites

An aerial view of the area containing observation sites 10 through 13 is shown in Figure 4. (For a view of this area during the winter exercises refer to Fig. 70c).

Site 10 (Figs. 6 and 7) A poorly drained, open black spruce and tamarack stand with a patchy shrub understory of willow and resin birch and a high percentage cover of sedges and grasses, primarily cottongrass, bluejoint reed-grass and common herbaceous horsetail.

Table 1. Vegetation Nomenclature

Common name	Botanical name
Black spruce	- *Picea mariana*
White spruce	- *Picea glauca*
Tamarack (larch)	- *Larix laricina*
Paper birch	- *Betula papyrifera*
Resin birch	- *Betula glandulosa*
Alder	- *Alnus crispa*
Willow	- *Salix* spp.
Bearberry	- *Arctostaphylos rubra*
Blueberry	- *Vaccinium uliginosum*
Cranberry	- *Vaccinium vitis-idaea*
Buffaloberry	- *Shepherdia canadensis*
Bunchberry	- *Cornus canadensis*
Cloudberry	- *Rubus chamaemorus*
Labrador tea	- *Ledum groenlandicum*
Prickly rose	- *Rosa acicularis*
Horsetail	- *Equisetum* spp.
Fireweed	- *Epilobium angustifolium*
Iris	- *Iris* spp.
Winter cress	- *Barbarea* spp.
Goosefoot	- *Chenopodium rubrum*
Sedge	- *Carex aquatilis*
Cottongrass	- *Eriophorum angustifolium*
Tussock Cottongrass	- *Eriophorum vaginatum*
Bluejoint reedgrass	- *Calamagrostis canadensis*

Most of the surface vegetation had been removed by the bulldozer blade down to the surface of the organic soil. Since many roots and rhizomes were left in place, rapid sedge and grass regrowth has occurred within the trail. Thaw depth in the trail was approximately 1 m, and in the adjacent undisturbed area approximately 80 cm.

Site 11 (Figs. 8 and 9). Similar to site 10, except better drained with more continuous layer of black spruce and a few tamarack and almost complete cover by shrub understory of resin birch, buffaloberry and willow.

Trees and shrubs had been removed along with their roots, exposing large areas of organic soil. The revegetated grass cover on the trail varied from 1 to 80%, consisting mainly of cottongrass and a few tussock cottongrass with some bluejoint reedgrass and horsetail. Thaw depth in the trail was approximately 1 m, and in the adjacent area 90 to 95 cm.

Site 12 (Figs. 10 and 11). Drier than the previous two sites with a 5 m (approx.) black spruce overstory, a few taller willows and an extensive low shrub understory of labrador tea, bearberry, low bush cranberry and prickly rose, and a moss ground cover.

Because of the overstory density, removal of the trees with their roots had resulted in nearly complete removal of the surface vegetation mat, exposing dry organic soil. Vegetation cover on the trail was less than 10%, consisting of scattered seedlings of cottongrass. Some scattered debris from the trees remained on the trail surface. The thaw depth probe penetrated only 70 cm to what appeared to be gravel, not the frost line.

Site 13 (Figs. 12 and 13). A willow shrub thicket with scattered tamarack, resin birch, moss hummocks, bluejoint reedgrass and sedge.

The trail cut had been done with very little penetration of the bulldozer blade into the soil. Revegetation had produced a 20% vascular plant cover over the dried organic soil, the prominent species being tussock cottongrass, bluejoint reedgrass, horsetail, sedge and some willow. What appeared to be either the frost line or gravel was detected at a depth of 80 cm.

An aerial view of the area containing sites 14 and 15 is shown in Figure 5. (Refer also to Fig. 70b.)

Site 14 (Figs. 14 and 15). A poorly drained, well developed shrub-tussock community with cottongrass tussocks up to 1 m in diameter, scattered paper birch with numerous resin birch and willow species; species frequently occurring on the tussocks include cloudberry, labrador tea, and blueberry, as well as mosses.

Blade penetration had been down to the bottom of tussocks, near the natural water level. The vegetation cover was less than 10%, primarily bluejoint reedgrass and horsetail, with exposed, wet organic soil and ponded water elsewhere. Thaw depth in the trail was 60 to 65 cm, and 35 to 40 cm in the adjacent area (measured from the bottom of tussocks).

Site 15 (Figs. 16 and 17). Same original vegetation cover as at site 14.

At this location, blade penetration had been several cm below the bottom of tussocks, resulting in standing water, up to 10 cm deep, in the trail. Some bluejoint reedgrass and iris were observed in the water. Thaw depth was 70 cm below the water surface, and 31 to 36 cm in the adjacent area (measured from the bottom of tussocks). This site represents one of the deepest disturbances on the new trail, in terms of bulldozer blade penetration.

An aerial view of site 16 is shown in Figure 18, and of site 17 in Figure 19.

Site 16 (Figs. 20 and 21). A mixed paper birch (dominant) - white spruce stand with a tall understory of alder and willow (approx. 5 m.), indicating a relatively young stand.

Trees and other vegetation had been removed to a level even with the terrain surface. Some trees had been uprooted, exposing wet organic soil. Vegetation cover varied from 10 to 90% over the area, the dominant species being bluejoint reedgrass and horsetail with numerous willow seedlings. Thaw depth was greater than 1 m.

Site 17 (Figs. 22 and 23). A tall (5-m) alder-willow shrub community (similar to the understory at site 16), with a few paper birch and white spruce.

The surface disturbance was more severe than at the nearby site 16. Blade penetration and uprooting of some of the trees had resulted in several depressions deep enough to expose standing water. Vegetation cover varied from 0% in the exposed water areas to 80% in the drier, less disturbed locations, and included bluejoint reedgrass, horsetail, fireweed, prickly rose and bunchberry. Thaw depth was greater than 1 m.

An aerial view of site 18 is shown in Figure 24, and of site 19 in Figure 25.

Site 18 (Figs. 26 and 27). A mixed spruce-birch stand, similar to site 16, but better drained, with a 10% vascular plant cover, consisting of fireweed, winter cress, horsetails, sedges and scattered willows.

Disturbance has been comparable to that at site 16, with vegetation removed even with the terrain surface, exposing organic soil at intermittent locations. This site had been used for vehicle repair and maintenance.

Site 19 (Figs. 28 and 29). A stand of dead spruce with a low shrub understory (primarily willow) in a well drained area.

Blade penetration had been even with or slightly below the soil surface, resulting in areas of exposed, dry organic soil. Revegetation by grasses and willow seedlings had produced a cover of less than 50% of the trail surface. This site was later burned out during a forest fire.

An aerial view of site 20 is shown in Figure 31.

Site 20 (Figs. 32 through 35). A shrub-tussock community, adjacent to a spruce stand, similar to sites 14 and 15, but better drained, the dominant species being willows, resin birch, various berry bushes, grasses and mosses.

The surface vegetation had been removed even with or somewhat below the bottom of the tussocks, resulting in exposed organic soil for most of the trail surface. The regrown vegetation cover was less than 10%, and consisted of willows, prickly rose and grasses. Thaw depth in the trail was 50 to 55 cm, and 35 to 40 cm in the adjacent area (measured from the bottom of tussocks).

Other Sites

Troop concentration (artillery) (Figs. 36-39). This area has been used during previous maneuvers (for location refer to Fig. 3). The three old trails that converge toward the observation tower appear to have been cut a number of years ago. The lack of any significant berms along the trail edges implies little or no blade penetration below the terrain surface. While there is a healthy regrowth of grasses, very little regrowth of shrubs could be observed (Figure 38). For comparison, the new trail, on which Site 20 is located, is shown in Figure 39.

Some debris were found near the tower (Fig. 36), indicating troop activities, but generally the area had been cleaned up very well.

Trail over bog (Figs. 40 and 41; refer also to Fig. 70a). An open bog, with sedge and horsetail as dominant species and willows on moss covered high points, the vegetation mat floating on standing water 0.6 to 1 m deep.

The newly cut trail showed relatively little impact (only one edge of the trail is visible), since a minimum of surface or vegetation disturbance had occurred. Willows had been sheared off at the water level and some moss hummocks had been knocked loose.

Command post (Fig. 42) and Landing area (Fig. 43) are shown for record purposes only.

Troop concentration (Blair Lakes) (Figs. 44-57). The area contains an unpaved landing strip, a new trail (Fig. 50) and several old trails (such as shown in Fig. 51). Some vehicle tracks are visible on an old trail (Figs. 52 and 53), which are also detectable in the aerial view (at the intersection of the trails) in Figure 49.

A couple of typical bivouac sites are shown in Figures 54 and 55. A dump site, with ashes still visible, is shown in Figure 56. The communications center site is shown in Figure 57. The cleanup in all of these areas has been rather thorough. Some minor debris, such as sections of communications wire, ration containers, and empty cigarette packs, were well hidden by the vegetation. From the air, the only visible signatures at this particular area were the trails. A number of fuel drums were observed at other sites in the Blair Lakes area.

Tanana to Blair Lakes trail (Figs. 58-67). For record purposes, several aerial photos were taken of the trail which was used during the last maneuvers as an access route to the Blair Lakes area from a road on the east bank of the Tanana River.

The location where an ice bridge was built from the east shore to the river, is shown in Figure 58. Removal of trees between the road and the river and some grading of the bank are the only obvious signs of disturbance. The river crossing, which was done over an area similar to that shown in Figure 59, left no visible marks.

The beginning of the trail on the west bank of the river is shown in Figure 60, and the continuation of the trail toward west in Figures 61 through 67. In one poorly drained area (Fig. 65), vehicle trails were observed off the original trail which showed noticeable subsidence and had resulted in a depression below the water level. Ground inspection was made at one location on the trail to observe the vegetation regrowth (Figs. 68 and 69).

It was understood that this is an old trail which had been rebulldozed prior to the recent maneuvers. Judging from the age of the berms along the edges of the trail and the vegetation regrowth in the trail, it was apparent that in most areas the recent trail preparation had been confined to snow removal without additional disturbance to the terrain surface or to the vegetation.

A number of snowmobiles had been used during the maneuvers as ground reconnaissance vehicles. Since the snow cover had absorbed whatever impact was produced by the snowmobiles, no signatures of their tracks were visible on the terrain surface.

The principal observation sites, selected for both close and cursory annual monitoring, are summarized in Table 2, which includes a listing of the corresponding Figure (photograph) numbers for each site.

Figure 70 shows aerial views of 3 sections of the new trail SE of Clear Creek Butte shortly after the trail had been cut. Figure 70a shows the bog area where the bulldozer blade did not penetrate into the soil. This view contains the area shown in Figures 40 and 41. Figure 70b contains sites 14 and 15, where considerable vegetation and soil removal had occurred (refer to Fig. 5). Figure 70c includes sites 10 through 13 (refer to Figure 4).

SUMMARY AND CONCLUSIONS

During the 1977 winter maneuvers, a new trail suitable for wheeled vehicle traffic was prepared by bulldozers in the area between Clear Creek Butte and Blair Lakes, south of Fairbanks, AK. The objective had been to remove only the snow cover and standing vegetation; however, in some areas the bulldozer blade had penetrated below the soil surface, in some cases resulting in exposed water during the following thaw season.

To observe the short and long term effects of this type of trail preparation, as well as the effects of the subsequent traffic and related vehicle and troop activities on the terrain, a number of observation sites, representing the various degrees of initial impact or disturbance, were selected for annual monitoring of the soil-vegetation response.

Removal of the snow cover and surface vegetation above or even with the soil surface does not significantly disturb the root system and, therefore, encourages rapid revegetation by shrubs and grasses. The extent of potential revegetation decreases as the depth of bulldozer blade penetration increases. In addition, exposed soil and standing water can increase the thaw depth in areas of shallow (< 1 m) frost line due to decrease in albedo and decrease in the insulation properties of the terrain surface (lack of vegetation mat). In the case of exposed standing water, caused by excessive excavation combined with settlement due to frost line depression, continued degradation with time, instead of recovery, can occur.

The most severe terrain surface damage, caused by the trail preparation (bulldozing), occurred in areas with prominent microrelief, such as the tussock areas. The relatively level bog areas experienced the least impact.

Vehicular traffic had been confined to the prepared trails; therefore, no assessment could be made on the effects of off-road traffic. The trails constituted the only easily visible signatures of maneuver activities. Other troop activity signatures, such as bivouac sites, could be detected only during close reconnaissance on the ground. Troop concentration areas had been policed quite thoroughly after the 1977 winter maneuvers.

In general, it appears that, except for the trail cutting, military maneuvers such as those conducted by the 172nd Infantry Brigade during the winter of 1977, do not result in any significant environmental impact. This conclusion is made as a result of: 1) the apparently thorough cleanup after the exercises, and 2) the absence of any major off-road vehicle traffic, which may have left some noticeable impact, had heavy off-road vehicles been used. However, the bulldozer-cut trails, which were required in the absence of off-road vehicles, result in a significant impact, although the damage is limited to a relatively narrow, but long, area.

The selected observation sites will be monitored during the next few summers to observe the vegetation recovery in the trails.

Table 2. Summary of Observation Sites

Site	Figure No.			Bulldozer Blade Penetration (cm)*	Thaw Depth (9 Aug 77)		Remarks
	Aerial View	Ground			Trail (cm)	Adjacent (cm)	
		Trail	Adjacent				
Close Monitoring:							
10	4	6	7	0	100	80	Spruce-tamarack stand
11	4	8	9	0-5	100	90-95	" " "
12	4	10	11	0-10			" " "
13	4	12	13	0-5			Willow shrub thicket
14	5	14	15	0-10	60-65	35-40	Shrub-tussock community
15	5	16	17	10-20	70	31-36	" " "
16	18	21	20	0-5	>100	>100	Birch-spruce stand
17	19	22	23	0-15	>100	>100	Alder-willow shrub comm.
18	24	27	26	0-5	>100	>100	Spruce-birch stand
19	25	28	29	0-5	>100	>100	Burned spruce stand
20	30,31	32,35	33,34	0-10	50-55	35-40	Shrub-tussock comm.
Monitoring:							
Old Trail	30,31	38					Shrub-tussock comm.
New Trail	40,41	-		0			Open bog
New Trail	48	50		0-5			Shrub-dead spruce comm.
Old Trail	48	51					Shrub comm.
Tracks	49	52,53					Old trail
Dump site	-	56					Shrub comm.
Tracks	65	-					Spruce bog

*Below surface of organic soil

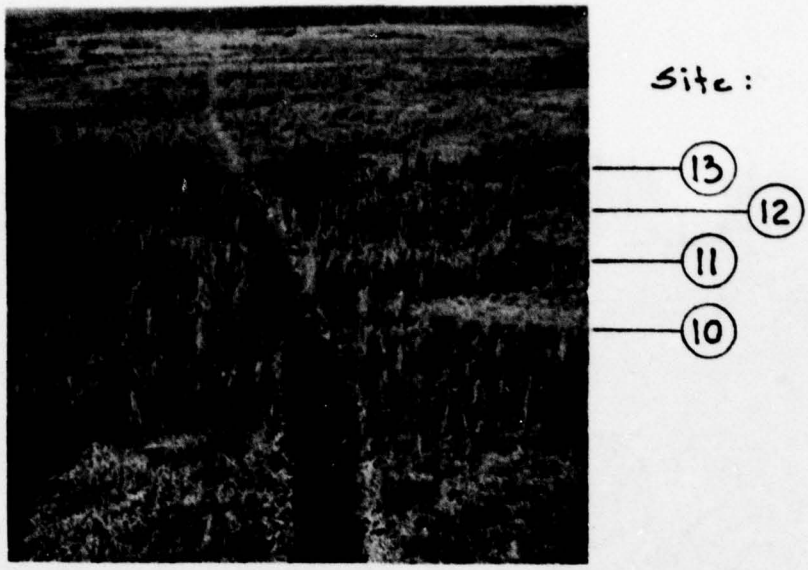


Figure 4. Aerial view of sites 10 to 13.

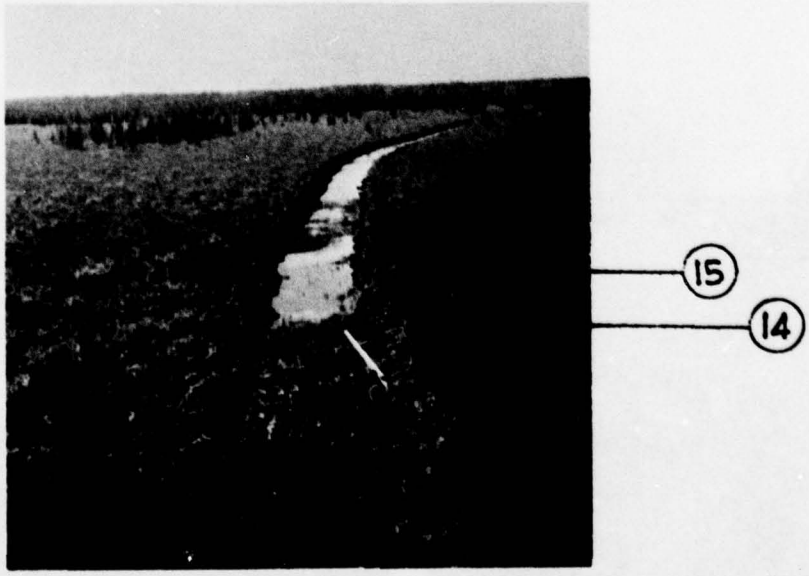


Figure 5. Aerial view of sites 14 and 15.

Figure 6. Site 10 (looking N).

Figure 7. Area adjacent to site 10 (looking E).

Figure 8. Site 11 (looking N).

Figure 9. Area adjacent to site 11 (looking E).

Figure 10. Site 12 (looking N).

Figure 11. Area adjacent to site 12 (looking E).

Figure 12. Site 13 (looking N).

Figure 13. Area adjacent to site 13 (looking E).

Figure 14. Site 14 (looking N).

Figure 15. Area adjacent to site 14 (looking E).

Figure 16. Site 15 (looking N).

Figure 17. Area adjacent to site 15 (looking E).

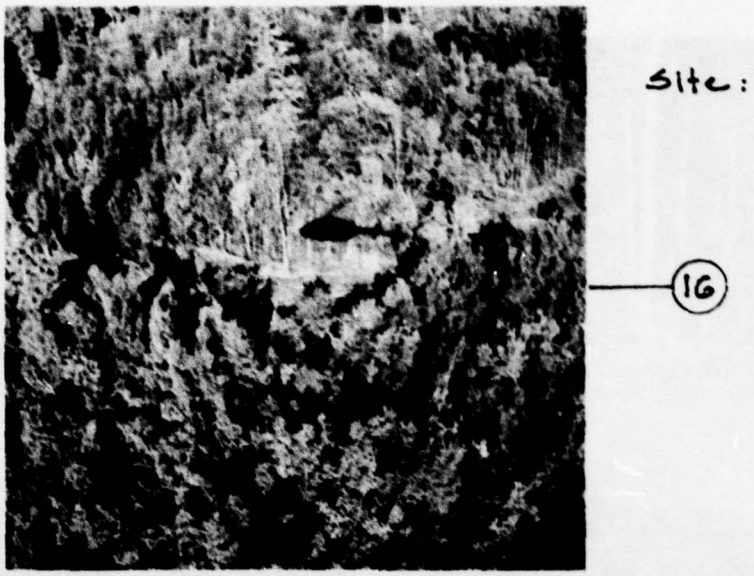


Figure 18. Aerial view of site 16.

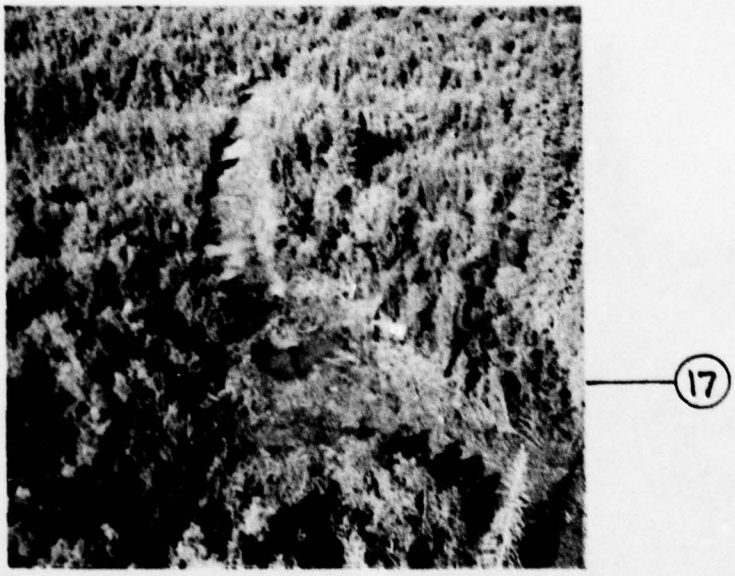


Figure 19. Aerial view of site 17.

Figure 20. Area adjacent to site 16 (looking E).

Figure 21. Site 16 (looking S).

Figure 22. Site 17 (looking N).

Figure 23. Area adjacent to site 17 (looking E).

Figure 24. Aerial view of site 18.

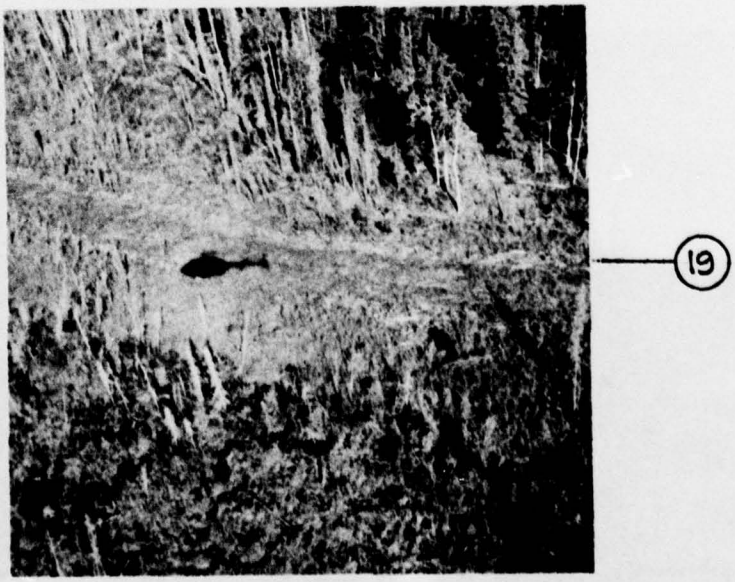


Figure 25. Aerial view of site 19.

Figure 26. Area adjacent to site 18 (looking E).

Figure 27. Site 18 (looking S).

Figure 28. Site 19 (looking N).

Figure 29. Area adjacent to site 19 (looking E).

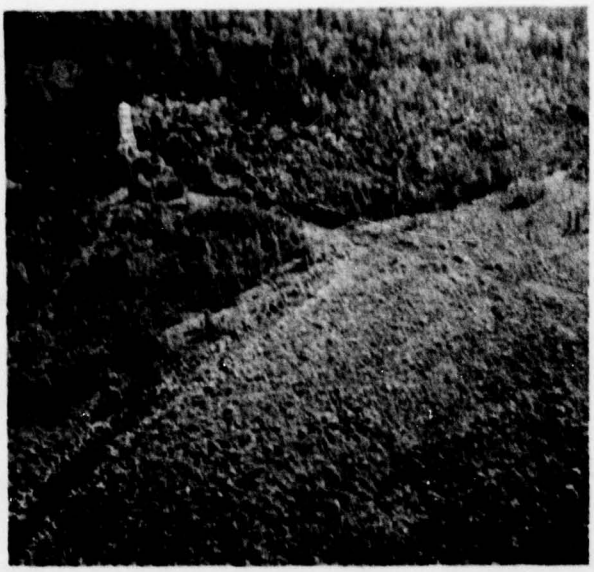


Figure 30. Aerial view of troop concentration (artillery) area and site 20 (looking SE).

Figure 31. Aerial view of site 20 (looking S).

Figure 32. Site 20 (looking N).

Figure 33. Area adjacent to site 20 (looking E).

Figure 34. Area adjacent to site 20 (looking W).

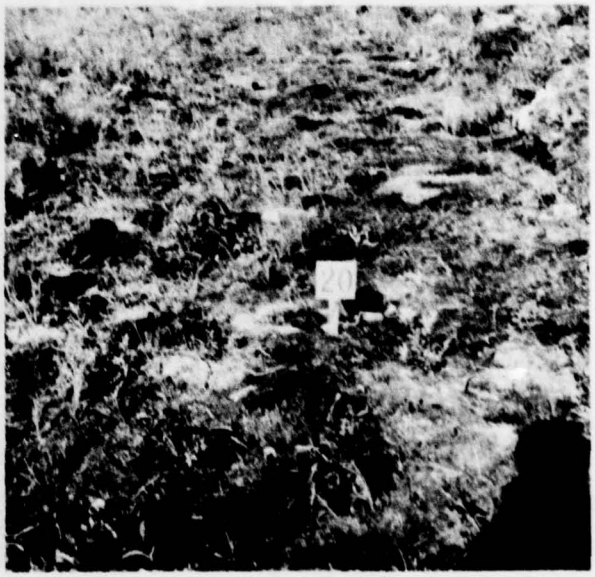


Figure 35. Site 20, closeup (looking N).

Figure 36. Troop concentration (artillery) area.

Figure 37. Trail at troop concentration (artillery) area (looking W).

Figure 38. Old trail (looking W).

Figure 39. New trail (looking N).

Figure 40. Trail with minor disturbance south of Clear Creek Butte (looking N).

Figure 41. Same trail (looking E).

Figure 42. Command post location north of Clear Creek Butte (looking N).

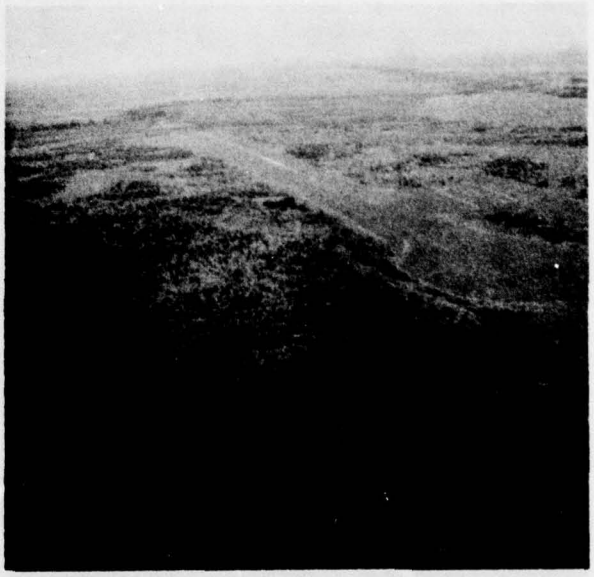


Figure 43. Clear Creek landing area (looking S).

Figure 44. Blair Lakes landing area (looking W).

Figure 45. Overall view of troop concentration and landing area (looking SE).

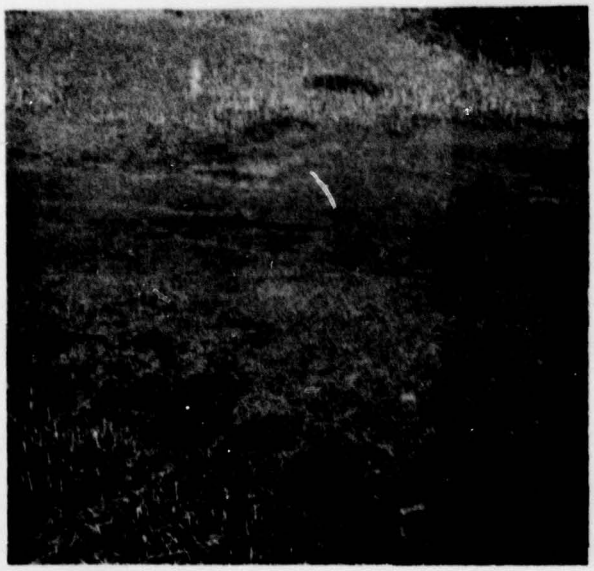


Figure 46. Western section of bivouac area (looking N).

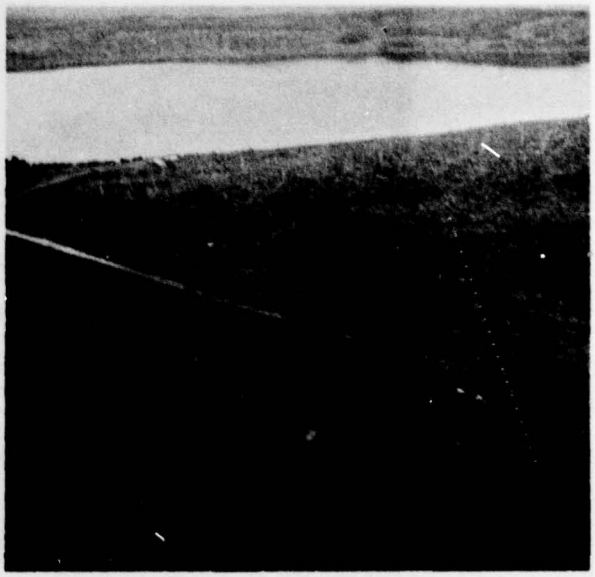


Figure 47. Landing area (looking S).

Figure 48. Eastern section of bivouac area (looking E).

Figure 49. Communications center area (looking S).

Figure 50. New trail (looking SE).

Figure 51. Old trail (looking E).

Figure 52. Vehicle tracks in old trail (looking E).

Figure 53. Vehicle tracks in old trail (looking S).

Figure 54. Bivouac site, north of trail.

Figure 55. Bivouac site, south of trail

Figure 56. Dump site.

Figure 57. Communications center site.

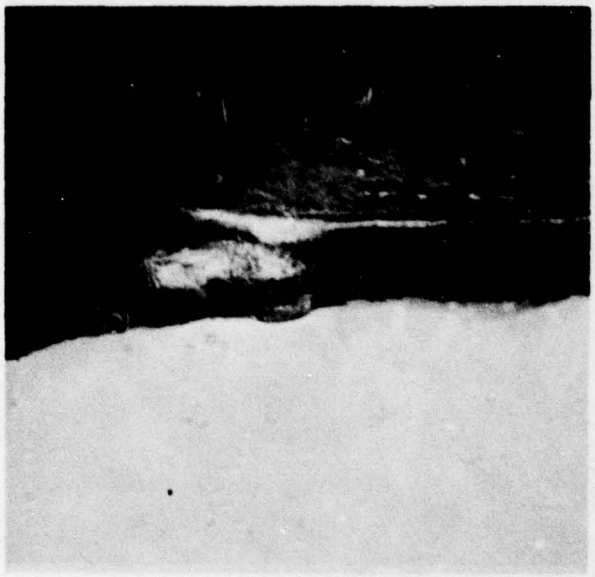


Figure 58. Location of ice bridge, east bank of Tanana River.

Figure 59. View of Tanana River SW of Eielson AFB (looking S)

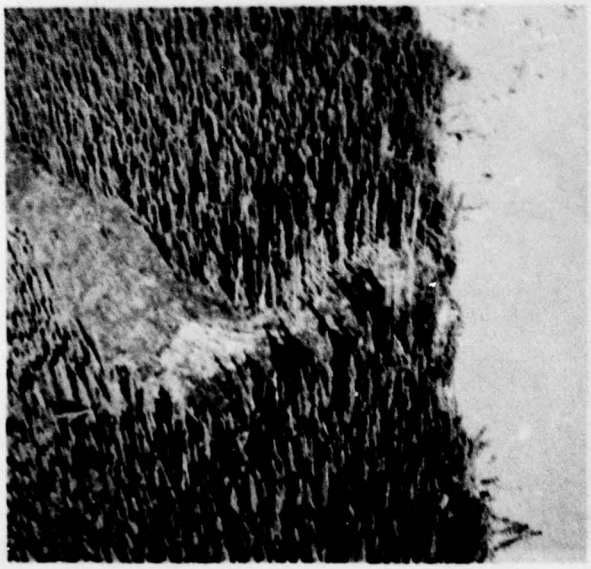


Figure 60. Beginning of trail, west bank of Tanana River.

Figure 61. Trail from Tanana River to Blair Lakes (looking W).

Figure 62. Tanana to Blair Lakes trail (looking NW).

Figure 63. Tanana to Blair Lakes trail (looking W).

Figure 64. Trails east of Blair Lakes (looking NW).

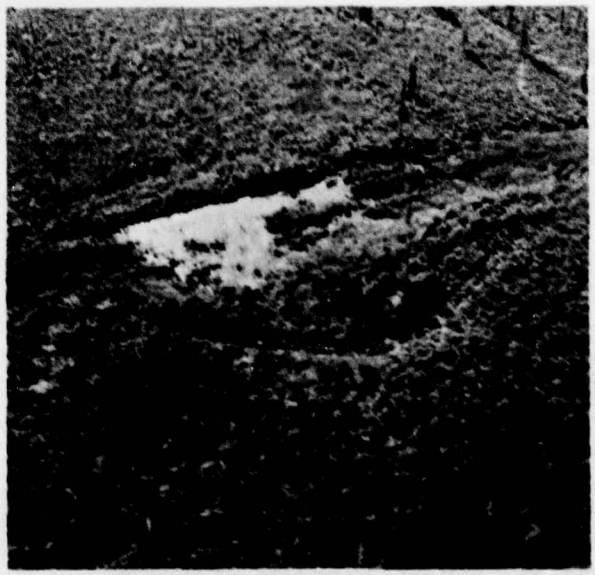


Figure 65. Trail through wet area.

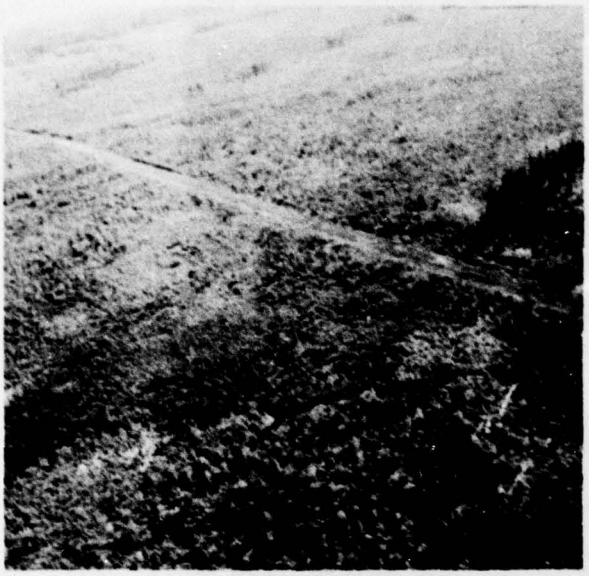
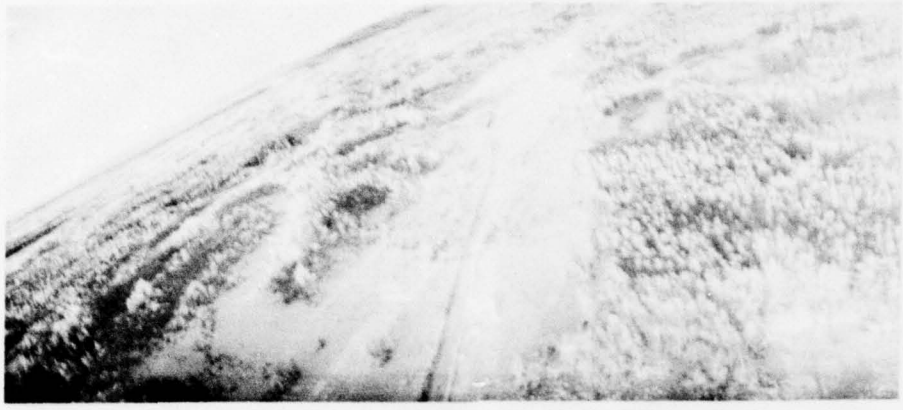


Figure 66. Tanana to Blair Lakes trail (looking SE).

Figure 67. Tanana to Blair Lakes trail (looking SE).

Figure 68. Ground view of trail (looking W).

Figure 69. Ground view of trail (looking E).



a) Bog area, including site shown in Figures 40 and 41

b) Area including sites 14 and 15 (Fig. 5)

c) Area including sites 10 through 13 (Fig. 4)

Figure 70. Newly cut trail SE of Clear Creek Butte (looking NW)